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27 March 2020

Version of attached file:

Accepted Version

Peer-review status of attached file:

Peer-reviewed

Citation for published item:

Simons, Jon S. and Mitrenga, Kaja and Fernyhough, Charles (2020) 'Towards an interdisciplinary science of the subjective experience of remembering.', *Current opinion in behavioral sciences.*, 32 . pp. 29-34.

Further information on publisher's website:

<https://doi.org/10.1016/j.cobeha.2020.01.018>

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Towards an interdisciplinary science of the subjective experience of remembering

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Acknowledgements

Preparation of this article was supported by James S. McDonnell Foundation Scholar Award #220020333 to JSS and Wellcome Trust award WT209513 to CF.

Highlights (3-5, each 85 characters incl spaces)

- Episodic memory can be better understood by considering different levels of analysis
- Arts and humanities depictions can inspire scientific investigation of remembering
- A multi-level perspective can help address some confusions in the literature
- Full understanding of memory requires consideration of social and cultural factors

Abstract (100-120 words)

Some of the most interesting advances in the study of episodic memory have come from considering different levels of analysis. In this article, we focus on how insights from multiple disciplines can inform understanding of the subjective experience of remembering. For example, we highlight how inspiration from the arts and humanities can generate novel research questions that can elucidate the cognitive and brain mechanisms responsible for what it feels like to remember a previous experience. We also consider how a multi-level perspective can help to address some confusions in the literature, such as between reconsolidation and reconstruction, and how a full understanding of memory requires appreciation of social and cultural factors.

Introduction

One of the reasons why psychology can be such a beguiling scientific discipline is the many different levels of analysis that can be brought to bear in seeking to understand the way in which humans think, feel and behave. While much has been learned from research focused on particular classes of explanation – cognitive accounts, computational models, cellular firing patterns, neural representations – some of the most novel and interesting advances have resulted from attempts to cut across levels of analysis. The quest to understand episodic memory is an excellent example of how multi-level perspectives can generate new research questions and yield fresh insights that might not have been possible with any single theoretical or methodological direction. However, we argue here that to continue advancing, and to tackle the most fascinating unanswered questions in the study of memory, we need to expand our inquiries beyond those levels of explanation that typically figure in scientific accounts. Our experience is that it can be fruitful to search for further inspiration in conceptions of remembering from the arts, humanities and social sciences, with their potential to unlock additional relevant levels of analysis for the study of memory.

The subjective experience of remembering

One way in which a multi-level approach to considering memory can be invaluable is in understanding the processes underlying the subjective experience (or phenomenology) of remembering. Psychologists and cognitive neuroscientists have made limited progress in investigating subjective aspects of remembering, sometimes struggling even to know what questions to ask in order to be able to tap into what it feels like to have a memory [1]. This is one area where the insights of novelists, poets and philosophers can usefully be brought to bear on the development of new scientific methodologies. As we shall argue, such an interdisciplinary approach has already begun to demonstrate its value in highlighting some key characteristics of recollection that can be tested empirically, helping to shed light on the cognitive and brain mechanisms responsible for the subjective experience of remembering.

The subjective experience of an act of remembering is richly represented in the arts and humanities, particularly in literary texts dating back to the classical era. Vivid descriptions of what it can feel like to remember something can, for example, be found in the writings of the novelist Virginia Woolf, particularly her autobiographical 'A Sketch of the Past' [2]. Her account of her earliest memory, of lying in her cot at the

family holiday house at St Ives, emphasises the multisensory nature of memory, particularly its incorporation of sights, sounds and emotions: 'hearing the blind draw its little acorn across the floor as the wind blew the blind out ... lying and hearing this splash and seeing this light, and feeling, it is almost impossible that I should be here...' (p. 64). Furthermore, writers such as the poet William Wordsworth highlight how our memories are tied closely to our own perspectives as experiencers, such that we typically re-live events from our original point of view: 'Oh! many a time have I, a five years' Child, / ... / Made one long bathing of a summer's day, / Bask'd in the sun, and plunged, and bask'd again' [3]. The ability to remember events from a first-person perspective helps us with the challenge of distinguishing real experiences from those we might have imagined or been told about by someone else. As Lord Byron wrote in 'Detached Thoughts' [4], 'It is singular how soon we lose the impression of what ceases to be constantly before us ... There is little distinct left without an effort of memory, then indeed the lights are rekindled for a moment – but who can be sure that imagination is not the torch-bearer?'

Inspired by these insights from the arts and humanities in highlighting key characteristics of the subjective experience of remembering, it has been possible for psychologists and neuroscientists to begin shedding light on their underlying cognitive processes and brain mechanisms [5,6]. These advances are leading to an emerging conceptual understanding of how remembering involves reactivating sensory and perceptual features of an event, and the thoughts and feelings we had when the event occurred, integrating them into a conscious first-person experience. One brain region that may play a key role in these processes is the angular gyrus area of the lateral parietal lobe, part of a brain network comprising multiple different regions such as hippocampus, posterior cingulate, precuneus, medial prefrontal cortex and parahippocampal cortex [7–13]. For example, Bonnici, Richter, et al. [7] found that brain activity in the angular gyrus does not differentiate between whether a participant is recalling auditory or visual memories, but is greater during retrieval of integrated audiovisual information (e.g., recalling the experience of an ambulance rushing down a street with its siren blaring). These findings complement those from a study that used brain stimulation to temporarily disrupt angular gyrus function in healthy volunteers, observing reduced performance on recollection tasks that require the multimodal integration of auditory and visual event features [13].

Other research has tested whether angular gyrus is also important for imbuing memories with the characteristic of first-person perspective that Wordsworth evoked

so powerfully [8,14,15]. For example, when volunteers were asked to recall autobiographical memories from their personal pasts, participants reported fewer of their memories as being experienced from a first-person perspective following angular gyrus disruption induced by brain stimulation compared with stimulation of a control brain region [8]. Of course, no single brain area functions in isolation, and evidence suggests that other regions become involved when we make judgments about the things we remember, such as the critical ability Byron identified of distinguishing events that actually occurred from those we might have imagined (or what we now term 'reality monitoring' [6,16]). Numerous brain imaging experiments have found that when people are asked to distinguish real from imagined experiences, an area of the brain that consistently exhibits activity is medial anterior prefrontal cortex, a region just behind the forehead [17–22]. Disturbed awareness of what is real may underlie some of the symptoms of clinical conditions such as schizophrenia. For example, hallucinations may result from misattributing imagined information as having occurred in the real world [23]. Consistent with this interpretation, structural and functional brain changes in the medial anterior prefrontal cortex region appear to be associated with confusion between real and imagined experiences, and to differentiate people with schizophrenia who hallucinate from those whose diagnosis is based on other symptoms, such as thought disorder [24–26]. Together, these findings begin to provide answers to the questions prompted by arts and humanities depictions concerning how we can experience our memories as rich and vivid multimodal events that are tied specifically to us, the person who originally experienced them.

One issue that is brought into sharper relief by this increased focus on personal accounts of remembering is the problem of integrating subjective and neural data. In the field of memory research, progress with this problem has been hampered by a reliance on prospective or retrospective reports, such as those typically made in a pre- or post-scan interview [27]. Such reports are of course susceptible to reconstructive errors, along with the potential introduction of biases around what an act of remembering is 'supposed' to be like. In-the-moment experience-sampling methods can avoid some of these pitfalls, and progress has recently been made in integrating arguably the most nuanced of such methods, Descriptive Experience Sampling, with fMRI [28,29]. While these studies have not to date been specifically focused on autobiographical recollection, they offer promise for the field in further integrating explanations at the subjective and neural levels of analysis. One lesson from such studies is that actual, ecologically situated moments of experience

frequently involve multiple, apparently contradictory elements (such as a simultaneous focus both on the internal and external worlds), and that such findings can be effectively understood in terms of neural activations predicting phenomenological data [30].

Integrating across levels of explanation

Closer attention to levels of analysis in episodic memory research may help to address some persistent sources of confusion in the literature. At the cellular level, there has been deserved interest in reconsolidation as a fundamental process in the formation of persistent memory traces [31,32], pointing to a mechanism by which memories can be changed by subsequent events. This is, however, likely to be a very different matter to the reshaping of memories through reconstruction that goes on at the supra-cellular (i.e., sub-personal or personal) level. While reconsolidation may provide a basic molecular mechanism through which *any* memory trace can subsequently be modified, it does not in itself explain why, for example, particular biases or incorporation of irrelevant information shape memory reconstruction (and thus contribute to human beings' distinctive memory errors). Much of the data concerning reconsolidation comes from experiments involving non-human animals, whereas the evidence that reconsolidation processes might influence human memory is more limited and controversial [33,34]. Similarities between the two phenomena are often drawn upon to express the dynamic nature of memory, where reconsolidation and reconstructive elements of memory can be interlinked [35,36]. However, reconsolidation does not logically imply reconstruction, any more than the inference in the other direction holds [37]. To suppose otherwise is to make a potentially dangerous confusion of one level of explanation with another.

Just as an interdisciplinary multi-level approach can help us to avoid problematic confusions between levels of analysis, it can also highlight scope for effective integration across explanatory levels. As an example, consider the burgeoning research field addressing social and cultural influences on memory. Recent findings highlight the effects of social processing on remembering, including the phenomena of social contagion, memory conformity, and collaborative remembering [38–40]. The social aspect of memory is evident in the study of collective memories, which has received renewed interdisciplinary interest [41–44]. For example, a key question in the area of cultural memory is how remembered events can have a phenomenology or subjective quality for individuals who themselves did not experience them [45]. Cultural and contextual influences are also highly relevant to autobiographical

memories – the characteristics of which can differ on many levels, depending on the cultural background of an individual [44]. If social processes are as important for memory as recent research is suggesting them to be, our understanding is likely to be hampered if we restrict ourselves to personal or sub-personal levels of analysis. Instead, there will likely be an important role for explanations pitched at the social-psychological, sociological and cultural-historical levels.

In Figure 1, we present a brief schematic of some of the main levels of analysis relevant to investigating human episodic memory. The list of levels is not exhaustive, nor is the table complete. One benefit of this kind of classification is that it allows us to ask whether certain features or phenomena can usefully be investigated at more than one level of analysis. For example, we have seen that features of subjective experience such as multisensory integration and first-person perspective are typically understood (in cognitive neuroscience) at what can be termed the Personal level of analysis, but are also explored at the Cultural level in the discipline of cultural history. Asking what features and processes are shared between (and differ between) these levels can be a fruitful endeavour for both disciplines.

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By the same token, commonalities of process can usefully be explored at different levels, opening the possibility of new interdisciplinary linkages. For example, it is possible to identify common features between the process of reconstruction at the Personal level (such as how memory representations are modulated by new information not relevant to the original event) and memory conformity phenomena at the Social level (such as where an individual's memories are shaped by the testimony of other social agents). Modelling these commonalities using the combined tools of cognitive and social psychology, along with sociology and cognitive neuroscience, may prove highly productive for future research endeavours. We hope that summarising some of the important relevant distinctions to be made among levels of explanation will both stimulate future research into human remembering, and help to avoid some of the confusions that can follow when levels of explanation are not sufficiently clearly distinguished.

Conclusion

We have argued that memory researchers elide levels of explanation at their peril. In addition to protecting against problematic confusions on key issues in memory

research, a greater awareness of how memory can be understood at different levels of analysis presents exciting research opportunities. There is wisdom and insight about the workings of memory to be tapped in disciplines such as philosophy, sociology and the study of literary texts and other artworks from all eras. Embracing the range of different levels of analysis at which remembering can be understood can only benefit the science of memory.

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Figure 1: Levels of explanation relevant to the study of human episodic memory

Level of explanation	Example relevant phenomena	Example sources of evidence
Cultural	Collective memory National memory Transgenerational/Postmemory Cultural differences (e.g. individualistic vs collectivistic cultures)	Social history Oral testimony
Social	Co-remembering Memory conformity Social contagion Transactive memory Misinformation Disputed memories	
Personal	Reconstruction	Literary texts (fiction, memoir, film, etc.) Descriptive Experience Sampling Interviews and questionnaires
Cognitive	Multimodal integration Self-referential processing Reality monitoring	Behavioural data Cognitive tasks
Neural activity	Network patterns of functional connectivity (e.g., core recollection network, DMN) Neuromodulation effects	fMRI Neurostimulation
Cellular	Reconsolidation	Optogenetics Single-cell recording
Molecular		Pharmacological manipulations

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Declarations of Interest: none

Acknowledgements

Preparation of this article was supported by James S. McDonnell Foundation Scholar Award #220020333 to JSS and Wellcome Trust award WT209513 to CF.